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4 February 1966

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SYNCHRONOUS P-11

FEASIBILITY

ANALYSIS

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LOCKHEED MISSILES AND SPACE COMPANY

SPACE SYSTEMS DIVISION

SUNNYVALE, CALIFORNIA

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FOREWORD

The Synchronous P-11 Feasibility Analysis is presented in brief form consisting of technical considerations, program schedule, and program costs.

In addition, an appendix illustrating the feasibility of a multiple mission, has been included.

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SYNCHRONOUS P-11 FEASIBILITY ANALYSIS

TABLE OF CONTENTS

	Page
FOREWARD	1
FRONT PIECE	ii
TABLE OF CONTENTS	iii
SYSTEM REQUIREMENTS	1
P-11S SATELLITE COVERAGE	2
OPERATIONAL CONSIDERATIONS	3
INTERCEPT SYSTEM	4
INTERCEPT ANTENNAS	5
LOW FREQUENCY BAND	6
MIDDLE FREQUENCY BAND	7
HIGH FREQUENCY BAND	8
MISSION TWO PAYLOAD TYPICAL	9
P-11 SYSTEM	10
SYSTEM BLOCK DIAGRAM	11
SYSTEM SUMMARY	12
POTENTIAL BOOSTERS	13
INJECTION SEQUENCE	14

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SYNCHRONOUS P-11 FEASIBILITY ANALYSIS

TABLE OF CONTENTS (CONT)

	Page
P-11 CONFIGURATION	15
ASCENT PROFILE	16
ON-ORBIT PROFILE	17
INBOARD PROFILE	18
P-11 BOOSTER MOUNTING	19
TENTATIVE KICK STAGE	20
P-11 TENTATIVE KICK STAGE	21
POWER	22
POWER SYSTEM	23
POWER SYSTEM BLOCK DIAGRAM	24
SOLAR CELL ARRAY CHARACTERISTICS	25
GUIDANCE AND CONTROL	26
GUIDANCE AND CONTROL FUNCTIONS	27
CONTROL SYSTEM CONFIGURATION	28
PRIMARY ANTENNA ATTITUDE CONTROL	29
GUIDANCE AND CONTROL EQUIPMENT	30
ATTITUDE DISTURBANCES	31

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TABLE OF CONTENTS (CONT)

	Page
COMMAND DATA LINK	32
P-11 VEHICLE TIM, TRACKING AND COMMAND BLOCK DIAGRAM	33
GROUND SYSTEM BLOCK DIAGRAM	34
T. T. AND C. VEHICLE EQUIPMENT LIST	35
COMMAND SUMMARY	36
COMMAND LINK CALCULATIONS	37
DOWN LINK CALCULATIONS	38
SCHEDULE AND PRICING	39
SYNCHRONOUS P-11 PROGRAM	40
PRICE SUMMARY	41
APPENDIX	42
OPTION #1	43
OPTION #2	44

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SYSTEM REQUIREMENTS

VEHICLE SYSTEM

- SYNCHRONOUS SATELLITE LOCATED FOR CONTINUOUS COVERAGE OF USSR
- SECURE COMMAND CAPABILITY FOR REAL TIME CONTROL OF PAYLOAD
- ATTITUDE CONTROL AND POINTING FOR INTERCEPT ANTENNA
- SECURE DOWN LINK FOR INTERCEPT DATA
- PIGGY-BACK CONFIGURATION WITH KICK STAGE OPTION
- ONE YEAR LIFE

PAYLOAD SYSTEM

- FREQUENCY COVERAGE:
  - 125 - 250 MC (MISSION ONE)
  - 250 - 500 MC (MISSION TWO)
  - 1500 - 2000 MC (MISSION THREE)
- REAL TIME ADJUSTMENT OF INTERCEPT RECEIVER FREQUENCY, BAND WIDTH AND SENSITIVITY VIA DIGITAL DATA COMMAND LINK

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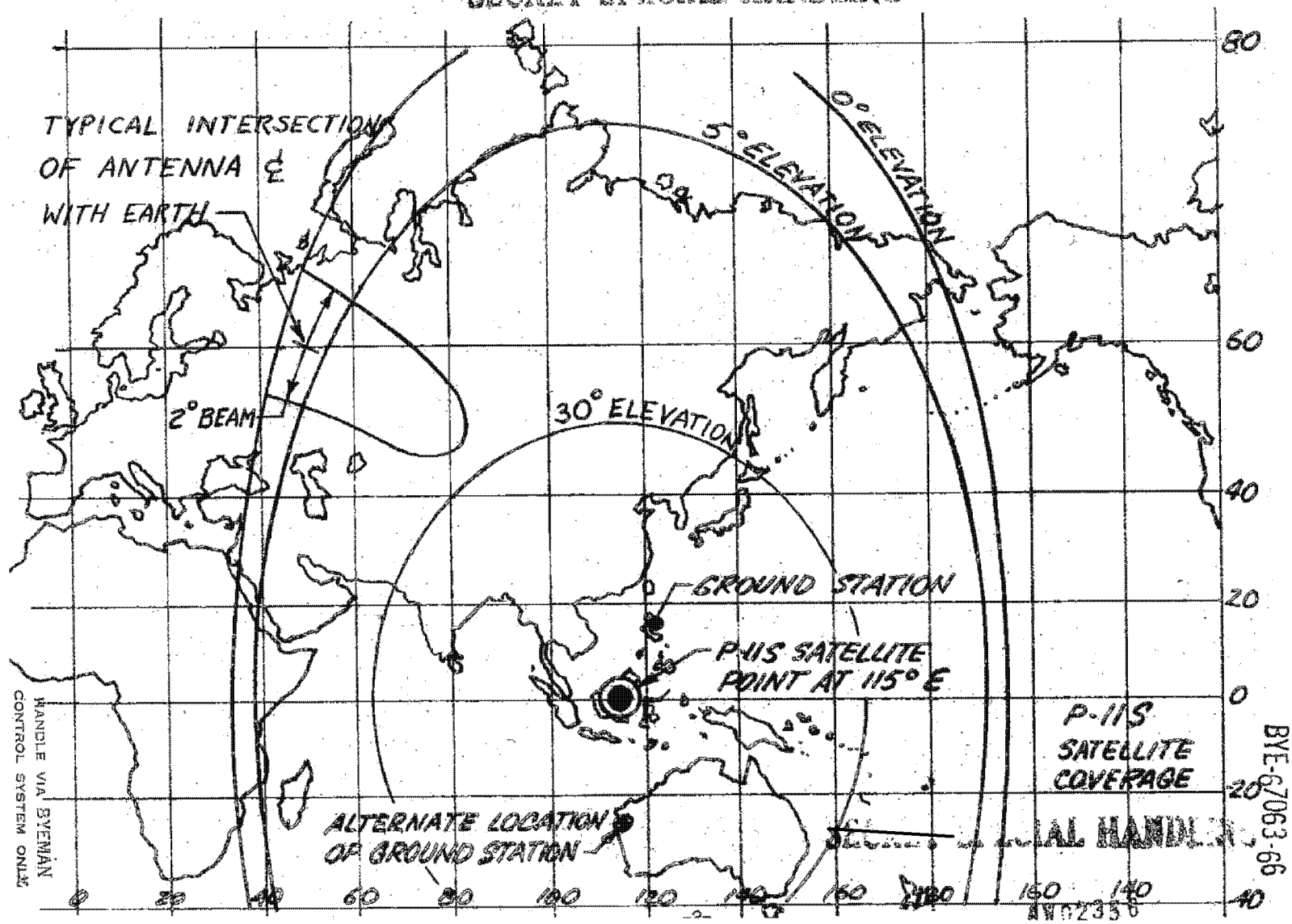

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OPERATIONAL CONSIDERATIONS

- VEHICLE TO BE LOCATED ABOVE EQUATOR AT THE PROPER LONGITUDE TO INSURE COVERAGE OF SOVIET UNION WHILE EXCLUDING INTERFERING SIGNALS FROM EUROPE.
- LOCATION OF RECEIVER ANTENNA BEAM MAY BE CONTROLLED BY GROUND COMMANDS STEERING VEHICLE IN PITCH AND ROLL.
- EAST-WEST VEHICLE POSITIONING CAN BE ACCOMPLISHED TO PICK UP SIGNALS NEAR THE HORIZON FOR VARIOUS LONGITUDES.
- ON-BOARD ENCRYPTION OF INTERCEPT DATA ALLOWS WIDE BEAM ANTENNA FOR DATA LINK AND CONVENIENT LOCATION OF GROUND STATION. EITHER AUSTRALIA OR THE PHILIPPINES REPRESENT SUITABLE SITES.
- NO ON-BOARD DATA STORAGE REQUIRED, THEREFORE NO TIME LOSS IN DATA ACQUISITION.
- OPERATION CAN BE CONTINUOUS. ONLY 1% OF THE VEHICLE LIFETIME IS SPENT IN THE EARTH'S SHADOW. A RECHARGEABLE BATTERY PROVIDES OPERATION DURING THIS PERIOD.

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INTERCEPT SYSTEM

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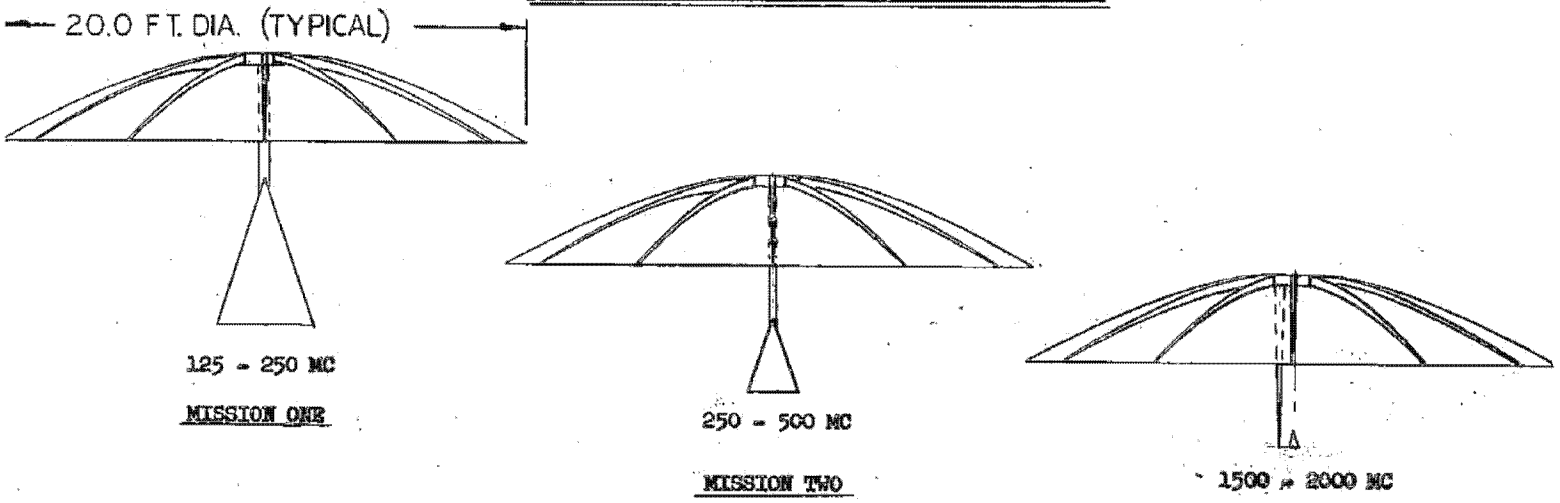
INTERCEPT ANTENNAS



MISSION CAPABILITIES

BAND	TYPICAL SIGNAL	CARRIER/NOISE*
125 - 250 MC	200W ERP (TYPE B & TYPE M)	9 DB (BACK LOBES)
250 - 500 MC	2.5W, 25W - 100W	+11, 21 and 27 DB (MAIN BEAM)
1500 - 2000 MC	30 WATTS PEAK	21 DB (MAIN BEAM)

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* WITH 20' DIAMETER ANTENNA ON VEHICLE.

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MISSION ONE

LOW FREQUENCY BAND

165 MC - TYPE B & TYPE M_2

183 MC - TYPE B & TYPE M_1

240 MC - TYPE M_1

o	XMTR PWR: 100 WATTS	+56 DBM	
o	XMTR ANTENNA GAIN:	- 3 DB	
	TARGET ERP	+53 DBM	(200 W ERP)
o	SPACE ATTENUATION = 172 DB		
o	RECEIVING ANTENNA GAIN = 18 DB (20' PARABOLA)		
o	RECEIVED SIGNAL STRENGTH = -101 DBM (+53 DBM +18 DB -172 DB)		
o	THERMAL NOISE FOR 1 MC RF BW	-114 DBM	
o	NOISE FIGURE	+ 4 DB	
	RECEIVER SENSITIVITY (S/N = 1)	-110 DBM	

S/N = +9 DB

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-6-

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MISSION TWO

MIDDLE FREQUENCY BAND

(360 - 420 MC)

			ERP	
			FRONT LOBE (+6 DB)	BACK LOBE (-5 DB)
o	XMTR #1 2.5 WATTS	+ 34 DBM	40	29
	#2 25.0 WATTS	+ 44 DBM	50	39
	#3 ? 100.0 WATTS	+ 50 DBM	56	45
o	SPACE ATTENUATION	176 DB		
o	RECEIVING ANT. GAIN (20' PARABOLA)	24 DB		
o	THERMAL NOISE (40 KC RF BW)	-128 DBM		
o	NOISE FIGURE	+ 5 DB		
	RECEIVER SENSITIVITY (S/N = 1)	-123 DBM		
o	CARRIER/NOISE XMTR #1		+11 DB	-
	#2		+21 DB	+10 DB
	#3		+27 DB	+16 DB

wrong BW
I think is 100 KC ≈ 5 DB difference

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MISSION THREE
HIGH FREQUENCY BAND
(1550 MC - 2000 MC)

o	XMTR PWR: 1.5 WATTS AVERAGE POWER DUTY CYCLE = 5%	
	PEAK PWR (30 WATTS)	+45 DBM
o	XMTR ANTENNA GAIN (MAIN BEAM INTERCEPT)	+23 DB
	TARGET ERP	+68 DBM
o	SPACE ATTENUATION = -190 DB	
o	RECEIVING ANTENNA GAIN = 37 DB (20' PARABOLA)	
o	RECEIVED SIGNAL STRENGTH = -85 DBM (+68 DBM +37 DB -190 DB)	
o	THERMAL NOISE FOR 2 MC RF BW	-111 DBM
o	NOISE FIGURE	+ 5 DB
	RECEIVER SENSITIVITY (S/N = 1)	-106 DBM
	C/N = +21 DB	

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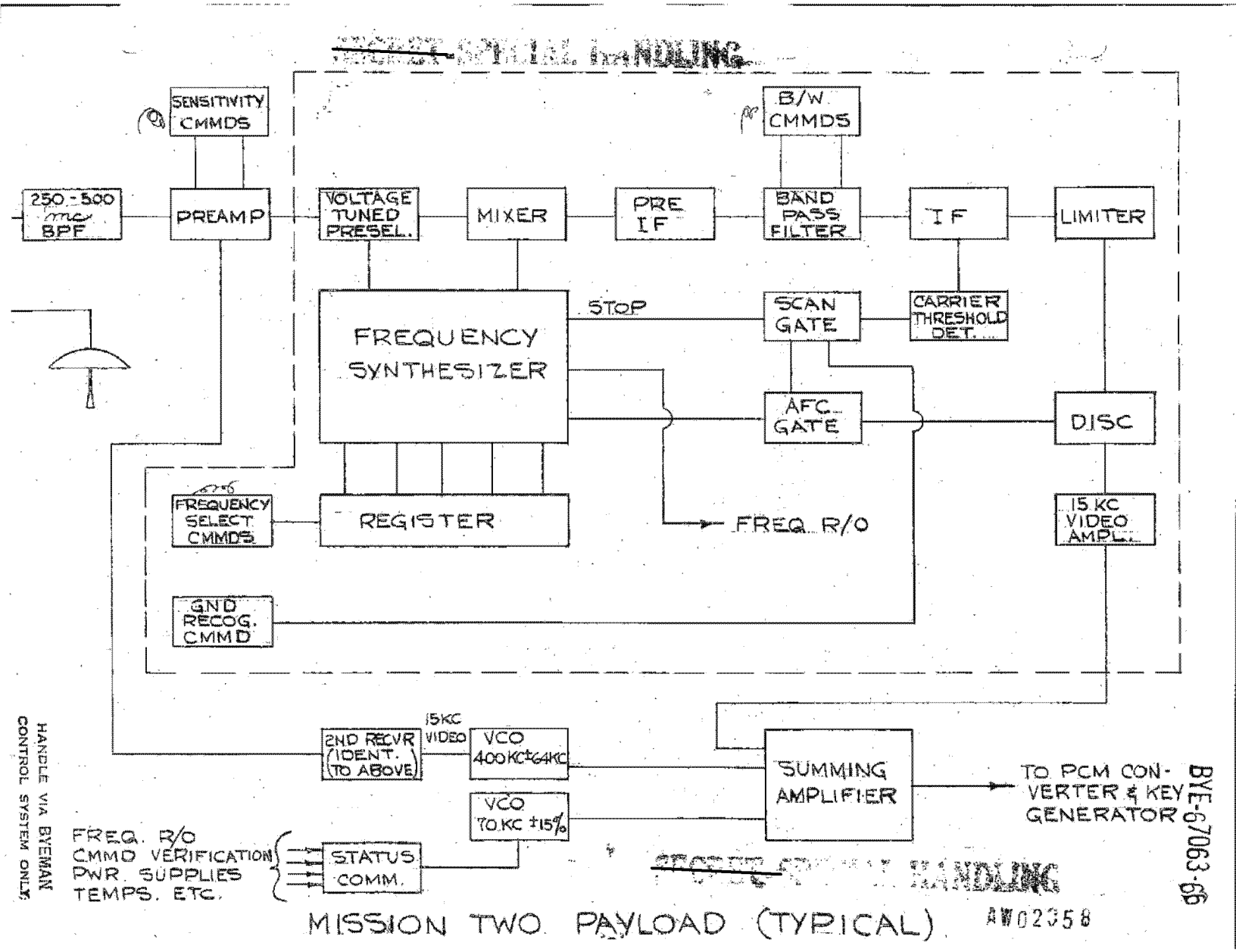

MISSION TWO PAYLOAD (TYPICAL)

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P-11 SYSTEM

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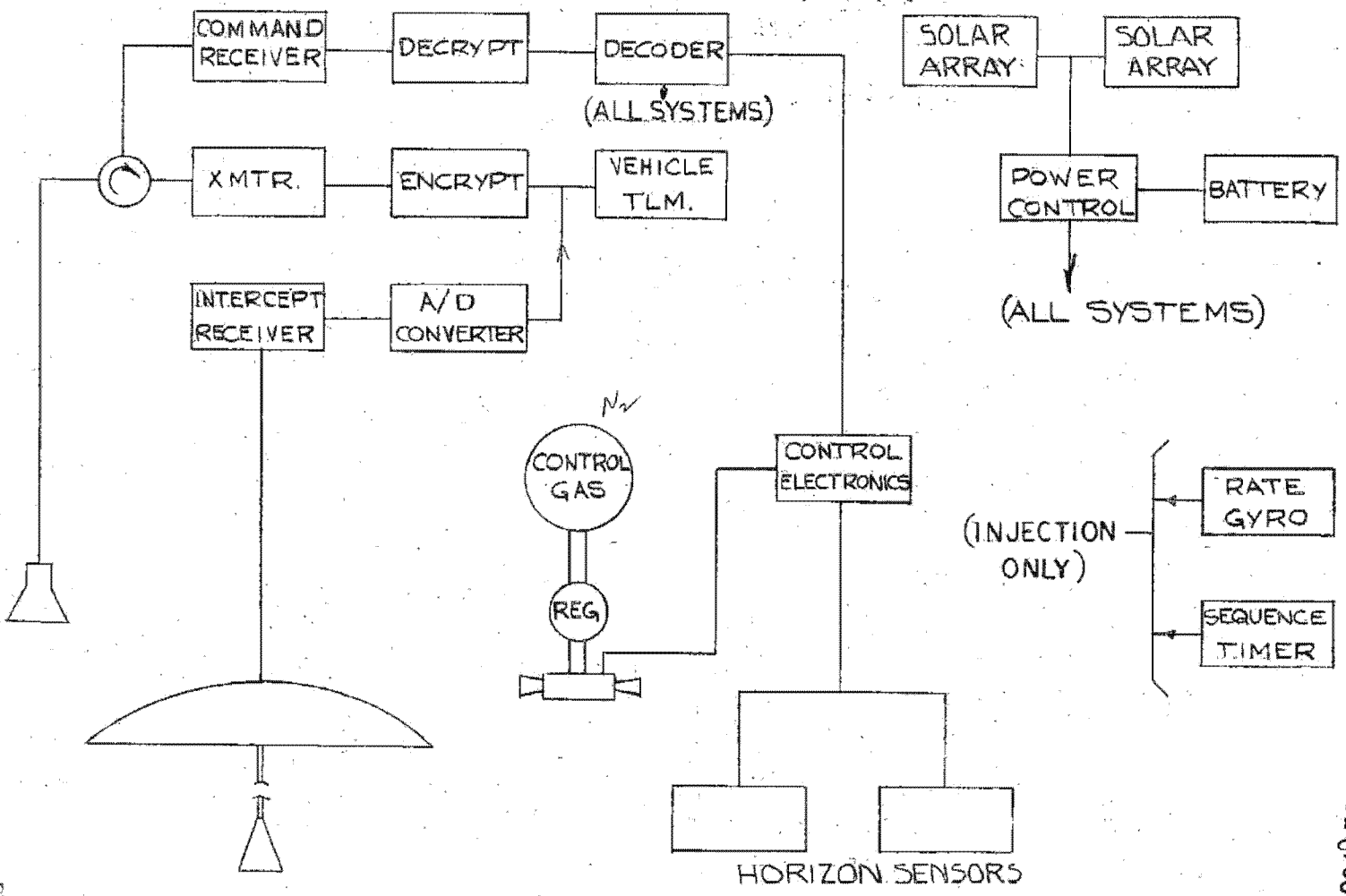

SYSTEM BLOCK DIAGRAM

~~Document is to be handled~~

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SYSTEM SUMMARY

			WEIGHT	POWER
o	STRUCTURE & THERMAL SHIELDS		36	
o	POWER SYSTEM		48	
	. SOLAR ARRAY, BOOMS & CONTROL	29		
	. BATTERY & CHARGE CONTROL	19		
o	ATTITUDE CONTROL & POINTING		63	17 (36 FOR ACQ.)
	. HORIZON SENSOR	14		
	. RATE GYRO PACKAGE	5		
	. SEQUENCE TIMER	3		
	. ATTITUDE CONTROL ELECTRONICS	5		
	. VALVES, BOOM, TUBING	12		
	. TANK & REGULATOR	24		
o	CONTROL GAS		54	
o	COMMUNICATIONS AND S/S COMMAND		11	15
	. RECEIVER	3		
	. DECRYPT	4		
	. DECODER	3		
	. ACQ. ANT.	1		

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SYSTEM SUMMARY (Continued)

			WEIGHT	POWER
o	DATA SYSTEM		33	32
	. DATA TRANSMITTER/MOD	14		
	. A/D CONVERTER	3		
	. ENCRYPTER (KG 26)	8		
	. STATUS TM	2		
	. CIRCULATOR	2		
	. DATA/COMMAND ANTENNA	3		
	. ANTENNA SWITCH	1		
o	PAYLOAD SYSTEM		55	25
	. INTERCEPT RECEIVER	15		
	. INTERCEPT ANTENNA	40		
o	HARNESS, RELAYS, ETC.		20	
		VEHICLE TOTAL	320	89 WATTS
		ADAPTER	10	
		GROWTH	20	
		SYS. DESIGN WT.	350	

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POTENTIAL BOOSTERS

BOOSTER USED TO ACHIEVE FINAL ORBIT

VEHICLE	TOTAL PAYLOAD WEIGHT ON FINAL ORBIT	P-11 WEIGHT	REMAINING WT. CAPABILITY FOR OTHER P/L IN FINAL ORBIT
TITAN III C (TRANSTAGE)	2200	350	1850
SLV-3X/CENTAUR	1400	350	1050
TITAN III CX/AGENA	2600	350	2250
TITAN III D/P-65	4800	350	4450

BOOSTER USED TO ACHIEVE TRANSFER ORBIT ONLY

VEHICLE	TOTAL PAYLOAD WEIGHT IN TRANSFER ORBIT	P-11 PLUS KICK STAGE WEIGHT	REMAINING WT. CAPABILITY FOR OTHER P/L IN TRANS.ORBIT
TITAN III C (TRANSTAGE)	7200	1075	6125
SLV-3X/CENTAUR	4200	1075	3125
TITAN III CX/AGENA	8600	1075	7525
SLV-3X/AGENA	2350	1075	1275

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INJECTION SEQUENCE

- VEHICLE IS INJECTED INTO EQUATORIAL PLANE 25 FPS BELOW SYNCHRONOUS VELOCITY BY BOOSTER OR KICK MOTOR PROVIDING A NOMINAL 2.5 DEGREE PER DAY EASTERLY LONGITUDE DRIFT
- VEHICLE SEQUENCER INITIATES FOLLOWING EVENTS:
  - DEPLOY CONTROL VALVE BOOM
  - DEPLOY SOLAR ARRAY BOOM
  - DEPLOY INTERCEPT ANTENNA
  - RATE GYROS OPERATE GAS VALVES TO REMOVE VEHICLE RATES
  - VEHICLE IS PROGRAMMED TO ROTATE ABOUT ALTERNATE AXES UNTIL HORIZON SENSORS LOCK ON
- VEHICLE IS ACQUIRED BY GROUND STATION
- RADIO LOCK SYSTEM ORIENTS VEHICLE IN YAW
- VEHICLE IS TRACKED TO MEASURE POSITION AND LONGITUDE DRIFT RATE
- STATION-KEEPING THRUST VALVES ADJUST VELOCITY TO BRING VEHICLE TO DESIRED LOCATION AND HOLD IT AT THAT POINT

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P-11 CONFIGURATION

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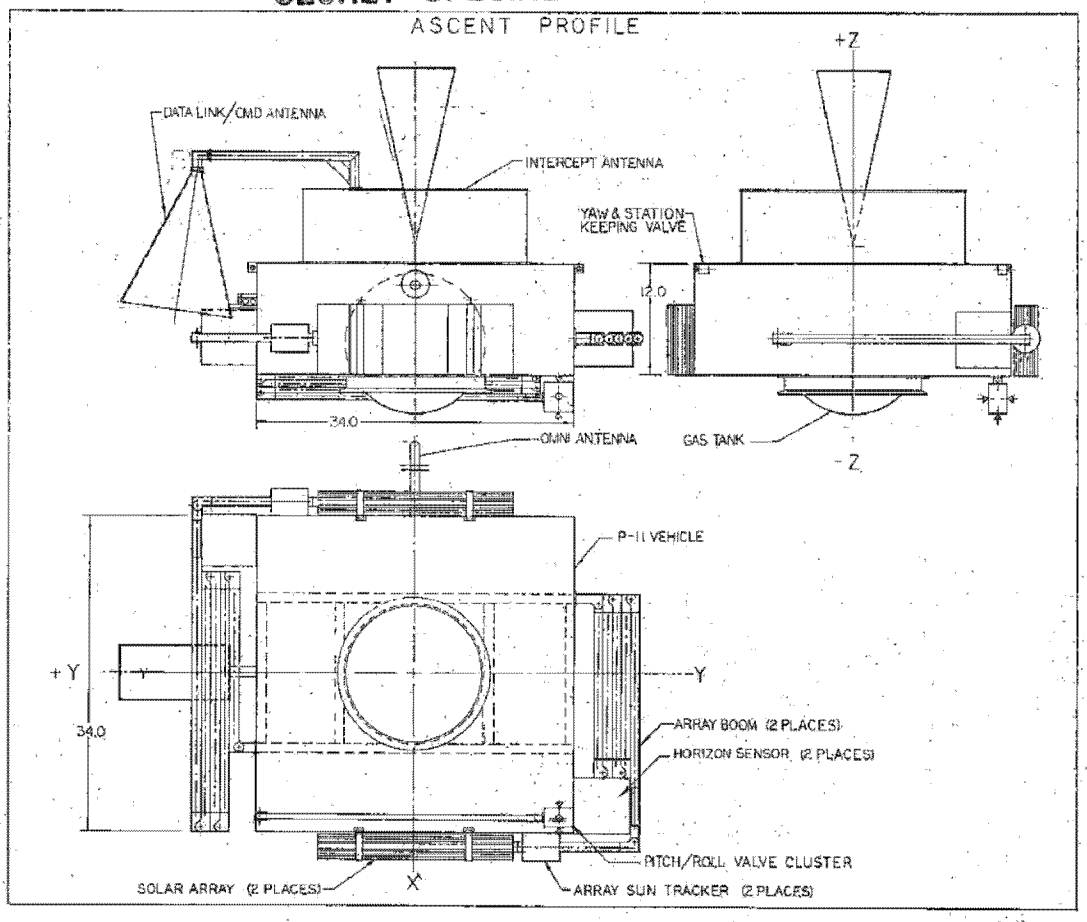

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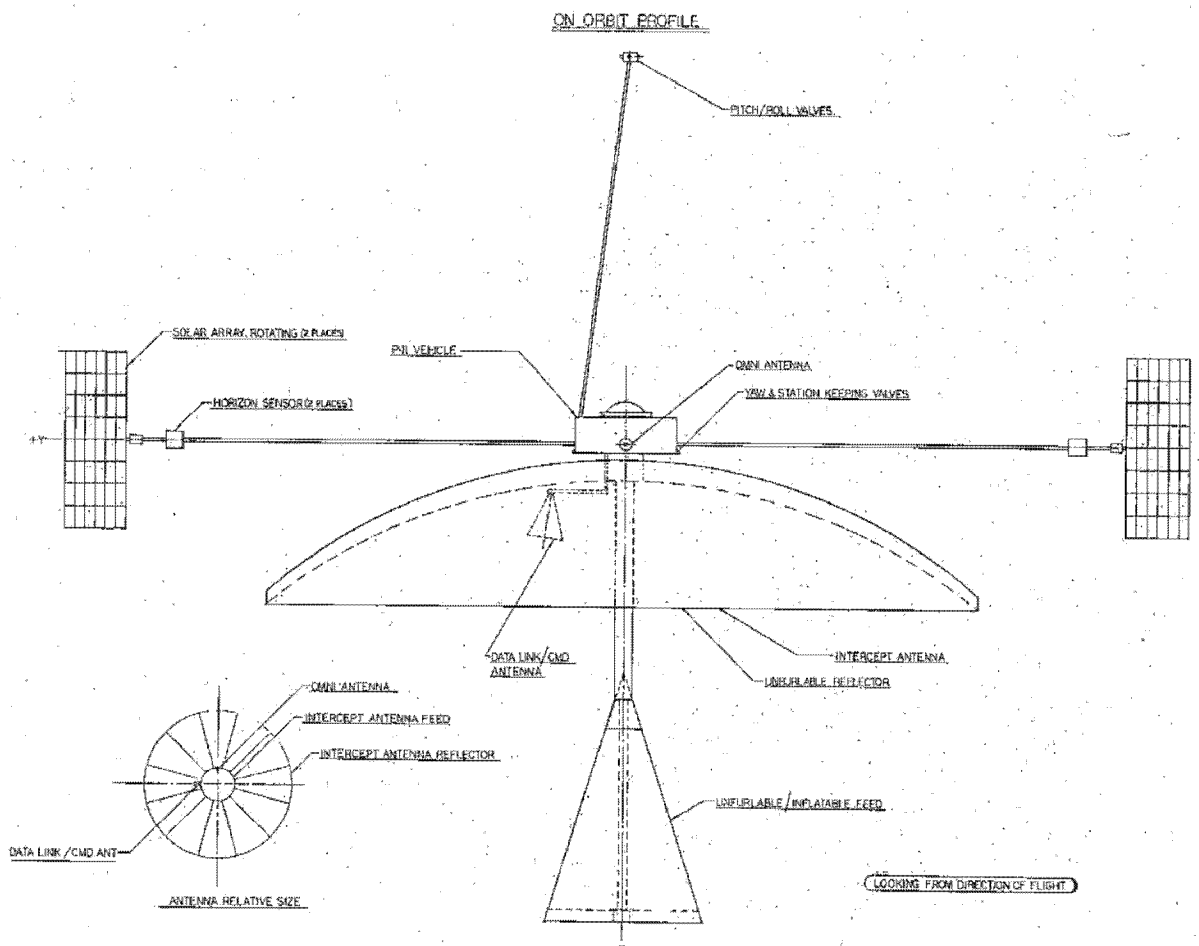

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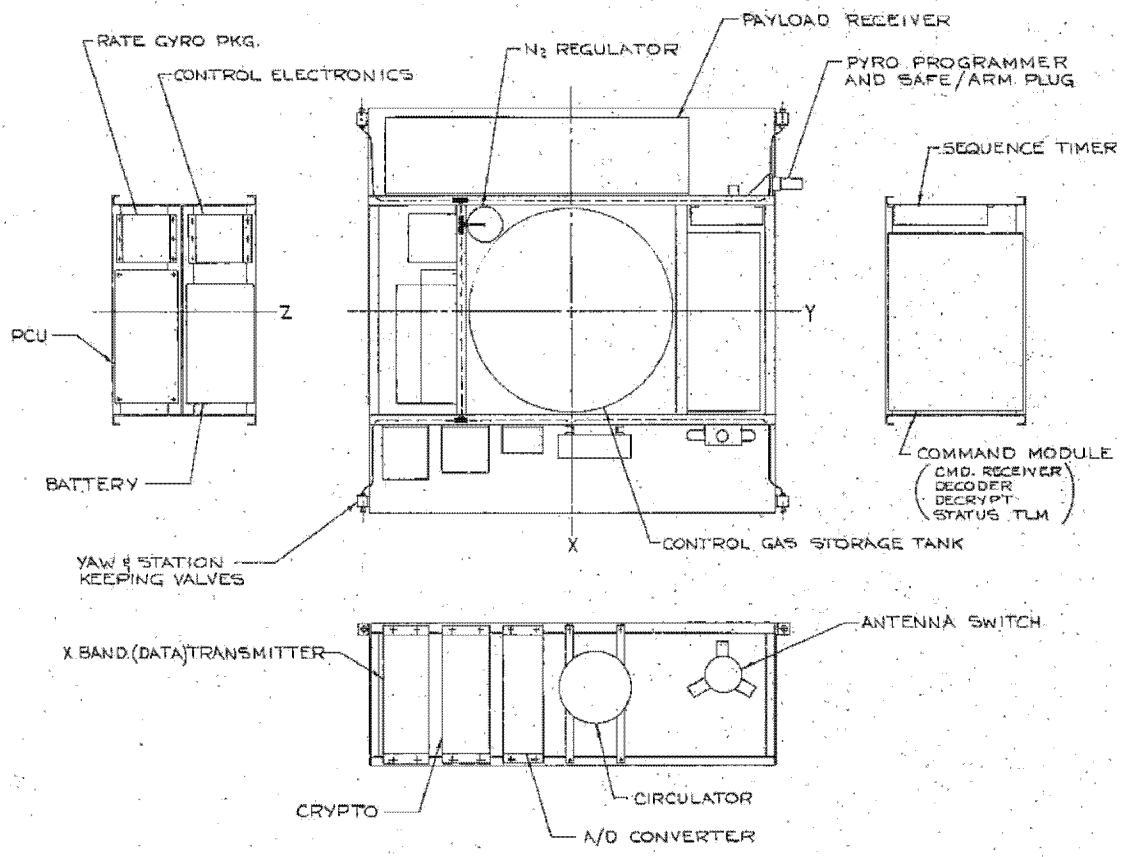
INBOARD PROFILE



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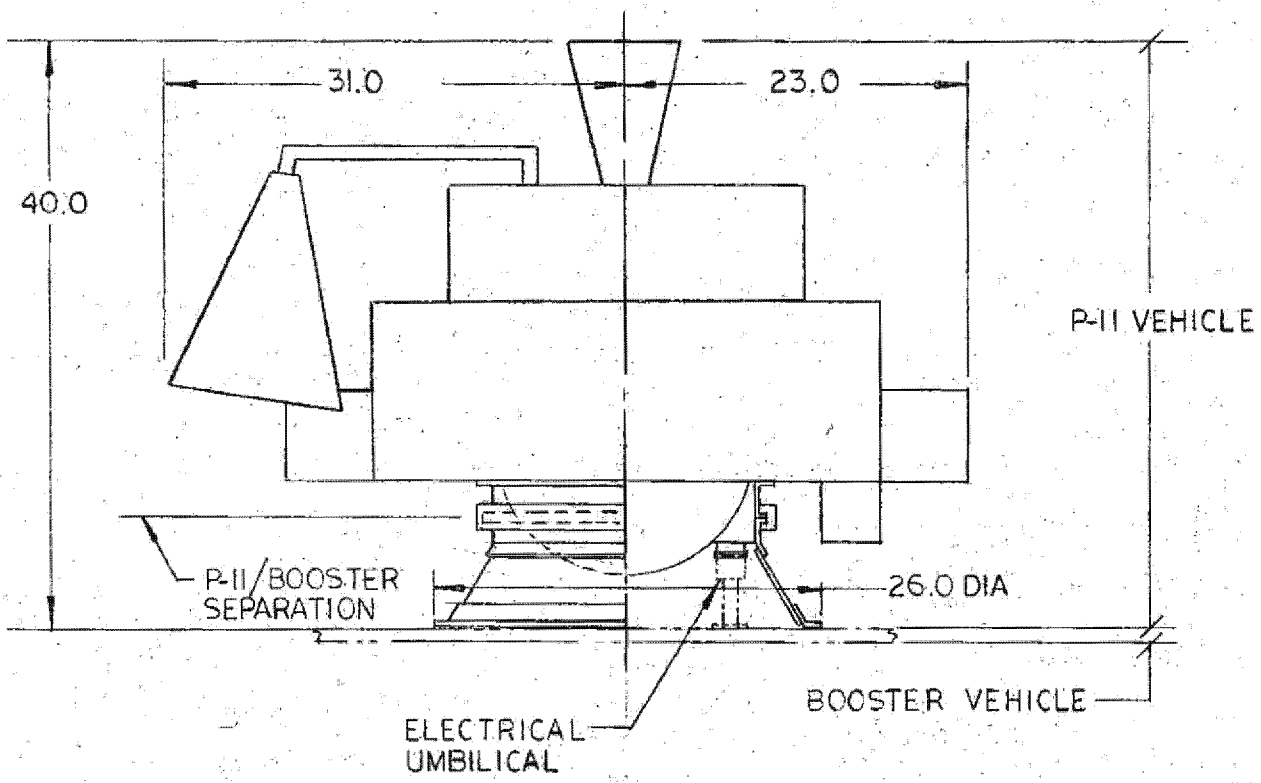
P-11/BOOSTER MOUNTING



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TENTATIVE KICK STAGE

- THE INCREASE IN VELOCITY REQUIRED TO CIRCULARIZE A 100 NM BY 19,323 NM TRANSFER ORBIT AND TO REDUCE INCLINATION FROM 26.2° TO ZERO IS APPROXIMATELY 5860 FT/SEC.
- THIS VELOCITY INCREMENT CAN BE PROVIDED BY A THIOKOL TE-M-442 SOLID PROPELLANT ROCKET MOTOR. THE MOTOR IS IN PRODUCTION STATUS AT THE PRESENT TIME FOR SANDIA CORPORATION.
- VERNIER VELOCITY AS WELL AS SPIN AND DESPIN WILL BE PROVIDED BY A HYDROGEN PEROXIDE SYSTEM. VELOCITY CUTOFF WILL BE DETERMINED BY A BELL VELOCITY METER. DESPIN WILL BE TERMINATED BY A RADIAL ACCELEROMETER.

MOTOR CHARACTERISTICS *

BURN TIME	16.22 SEC.
SPECIFIC IMPULSE	278.4 SEC.
AVERAGE THRUST	8750 LB.
TOTAL WEIGHT	592 LBS.
PROPELLANT WEIGHT	516.6 LBS.
MASS FRACTION	0.87
IGNITER	TE-P-443 PYROGEN

P-11/KICK STAGE WEIGHT SUMMARY

P-11 ON-ORBIT WEIGHT	350 LBS.
SUPPORT STRUCTURE	28 LBS.
HYDROGEN PEROXIDE SYSTEM	97 LBS.
VELOCITY METER & ACCEL-EROMETER	8 LBS.
KICK MOTOR	592 LBS.
TOTAL SYSTEM WEIGHT	1075 LBS.

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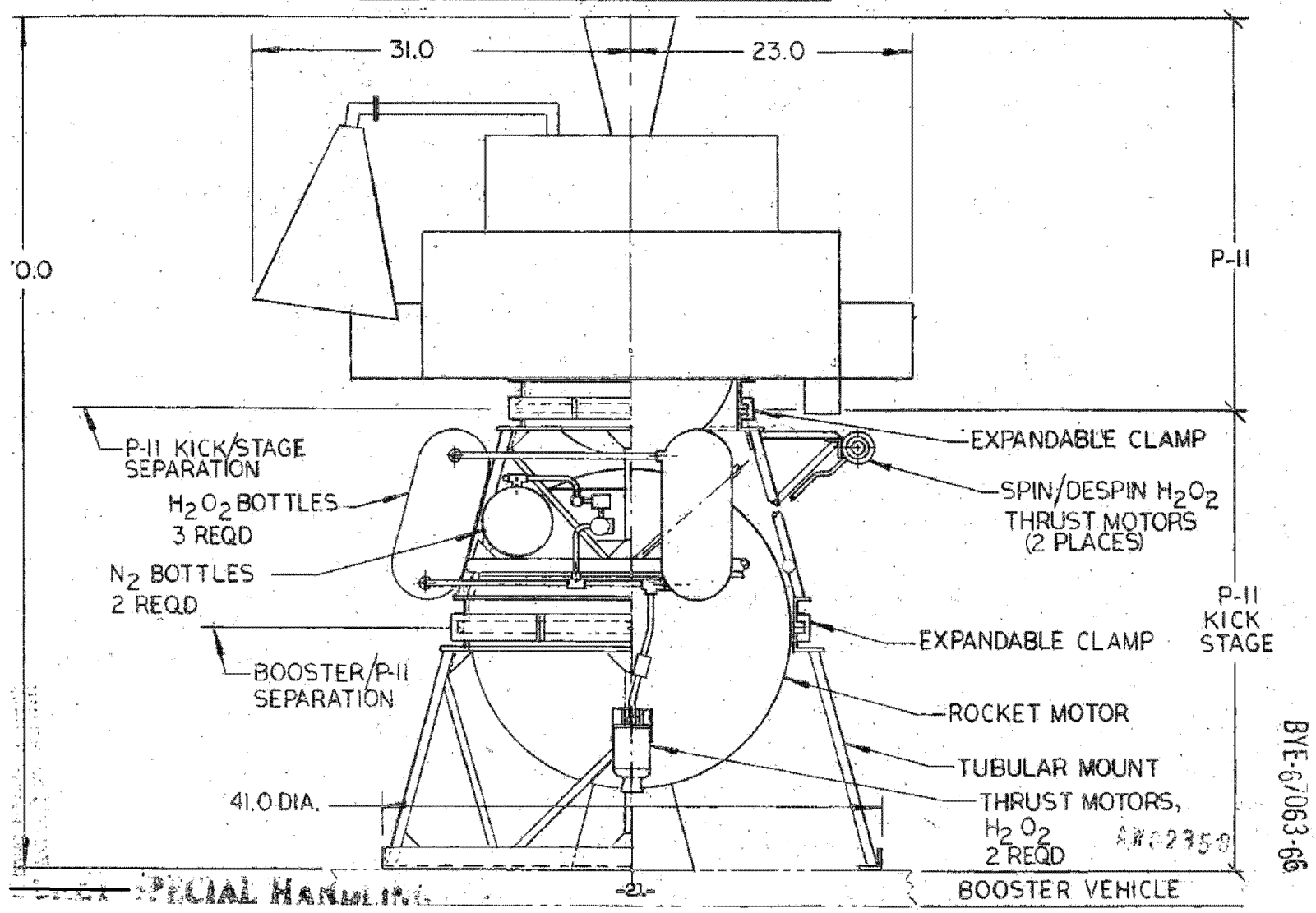
P-II TENTATIVE KICK STAGE



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POWER

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POWER SYSTEM

- TRACKING ARRAY - FIXED ON THE SUN
  - PROVIDES SMOOTH, NON-PULSING D.C. CURRENT
  - MINIMIZES NUMBER OF SOLAR CELLS REQUIRED
  - DRIVEN TO TRACK SUN AT CONSTANT RATE
  - EACH BOOM CONTAINS A COMPLETE DRIVE SYSTEM

- POWER CONTROL UNIT
  - KEEPS BATTERY FULLY CHARGED
  - PROTECTS AGAINST OVERCHARGE
  - PROTECTS AGAINST THERMAL RUNAWAY

- BATTERY PROVIDES POWER FOR:
  - INITIAL ACQUISITION AND CONTROL
  - ARRAY DEPLOYMENT AND INITIAL ORIENTATION
  - DARK PERIOD OPERATION OF 70 MIN/DAY FOR 95 DAYS/YEAR

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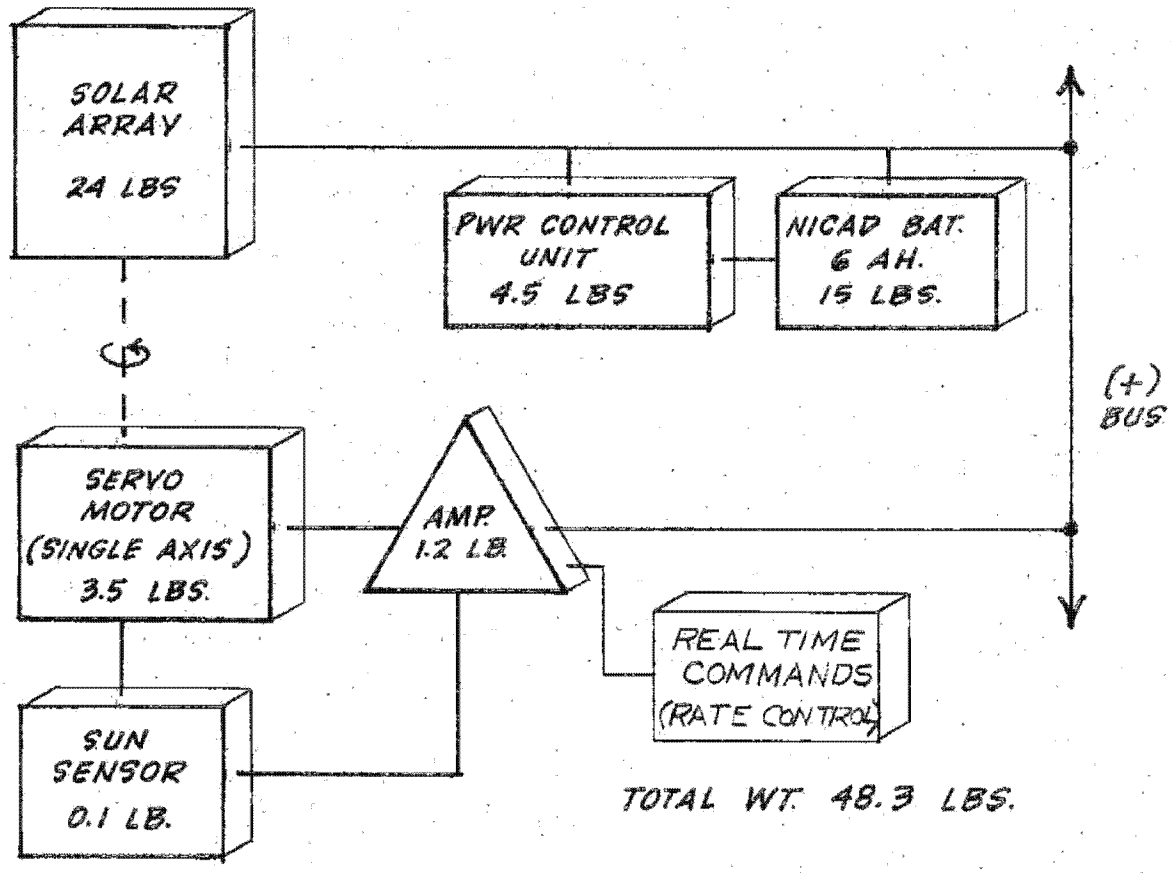
POWER SYSTEM BLOCK DIAGRAM



TOTAL WT. 48.3 LBS.

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SOLAR CELL ARRAY CHARACTERISTICS

- RADIATION DEGRADATION AFTER 1 YEAR: 25%

  THERMAL LOSS AT 120° F: 15%

- OUTPUT PERFORMANCE OF BASIC SOLAR MODULE
  - 79 CELL MODULE (SERIES CONNECTED)
  - 1.76 WATTS
  - 28 VOLTS
- OUTPUT PERFORMANCE OF SOLAR ARRAY
  - 48 MODULES PER WING
  - 2 WINGS

  } 96 MODULES = 7584 SOLAR CELLS
  - 169 WATTS AT START OF MISSION
- PROVIDES POWER REDUNDANCY AT START OF MISSION
- SECONDARY BATTERY PERFORMANCE
  - 6 AMP. HR.
  - MAX. DEPTH OF DISCHARGE 40%

89 watt system Estimated

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GUIDANCE & CONTROL

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GUIDANCE AND CONTROL FUNCTIONS

- ACQUISITION
  - RATE SEARCH.....RATE GYRO PKG.
  - CAPTURE AND HOLD.....HORIZON SENSOR
- PRIMARY CONTROL
  - PITCH AND ROLL CONTROL.....HORIZON SENSOR
  - YAW CONTROL.....POLARIZED UP-LINK
  - STABILIZATION.....PSEUDO RATE CONTROL
- STATION KEEPING.....DUAL YAW VALVES

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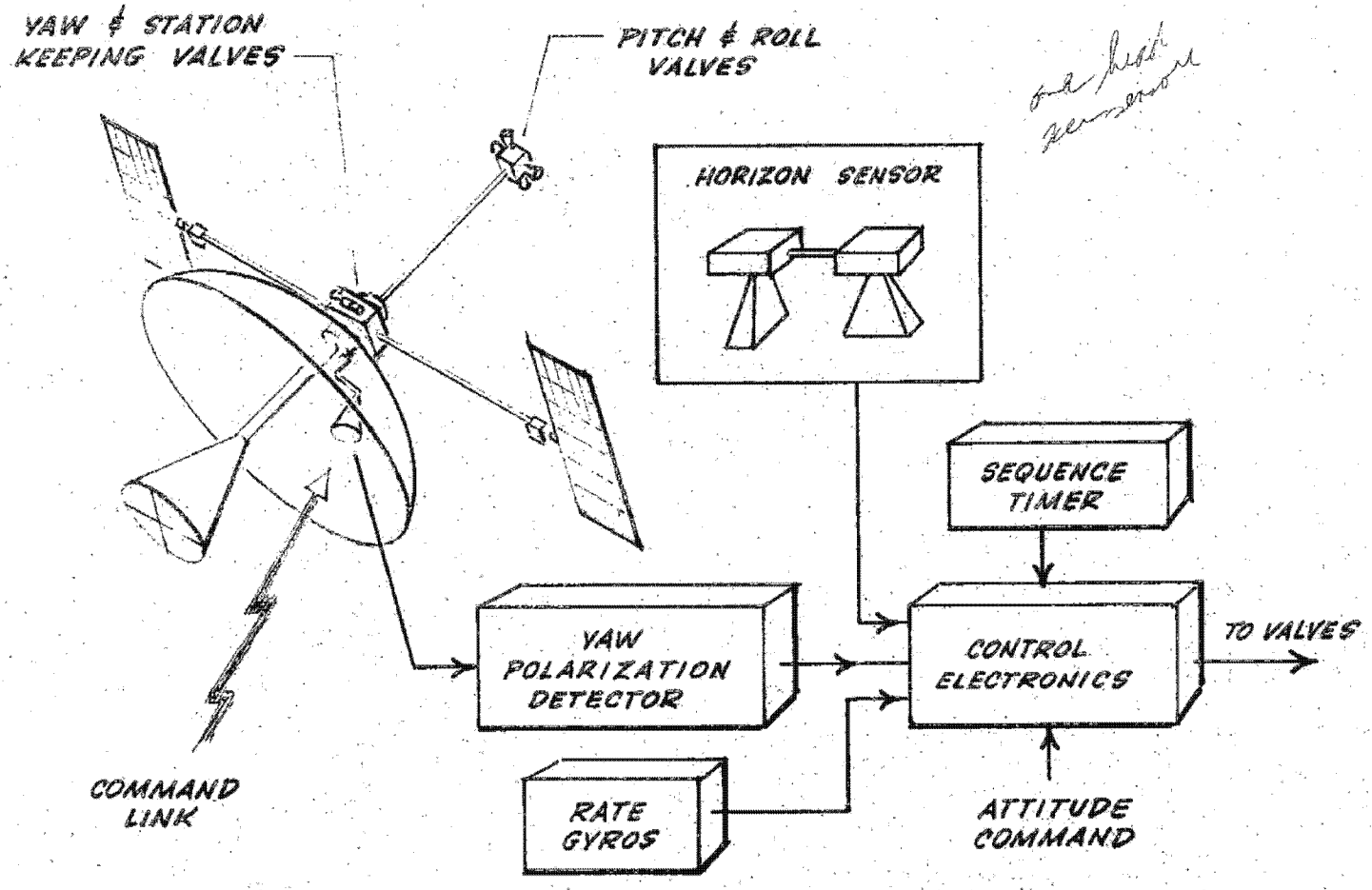
CONTROL SYSTEM CONFIGURATION



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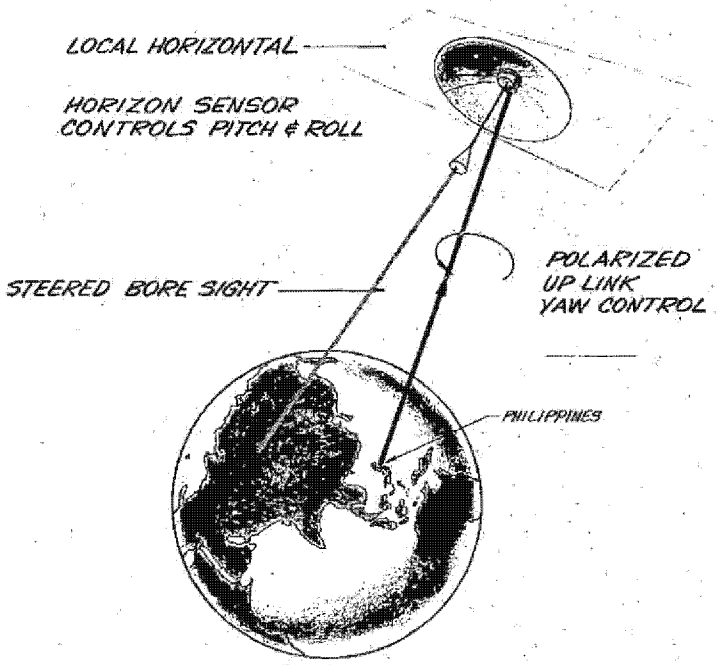
PRIMARY ANTENNA ATTITUDE CONTROL



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GUIDANCE AND CONTROL EQUIPMENT

		WEIGHT (LBS.)		POWER (WATTS)
o	ATTITUDE CONTROL			
	. RATE GYRO PACKAGE	5		18 (ACQ. ONLY)
	. HORIZON SENSOR	14		12 CONTINUOUS
	. CONTROL ELECTRONICS	5		5 "
	. TIMER	3		1 (ACQ. ONLY)
			27	
o	PROPULSION HARDWARE			
	. VALVES	6		
	. REGULATOR	1		
	. TANK	23		
	. PLUMBING	2		
	. BOOM	4		
			36	
o	STORED GAS			
	. ATTITUDE CONTROL	10		
	. STATION KEEPING	44		
			54	
	TOTAL		117 LBS.	17 WATTS (AVG. CONTIN.)

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ATTITUDE DISTURBANCES

			CONTROL GAS BUDGET FOR 1 YEAR
o SOLAR PRESSURE			
. DAILY AMPLITUDE	PITCH	7×10^{-5} FT LB	4 LB
	ROLL	3×10^{-5}	2 LB
	YAW	1×10^{-5}	3 LB
o MISCELLANEOUS DISTURBANCES			
. MAGNETIC, MICROMETEORITE, EARTH ALBEDO		50 LB SEC	1 LB
		ATTITUDE CONTROL	10 LB
o STATION KEEPING			
. VELOCITY CHANGE (180 FT/SEC/YR)		2000 LB. SEC.	40 LB
. YAW DISTURBANCE (DUAL VALVE)			0
. PITCH (ONE FOOT DISPLACEMENT)			4 LB
		STATION KEEPING	44 LB
		TOTAL	54 LB/YR

o STANDARD AGENA 2200 IN.^{3} TANK -9 MIX @ 3600 PSI HAS A CAPACITY OF 66 LBS.

HANDLE VIA COMINT CONTROL SYSTEMS ONLY

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COMMAND & DATA LINK

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BYE-5[illegible]-83

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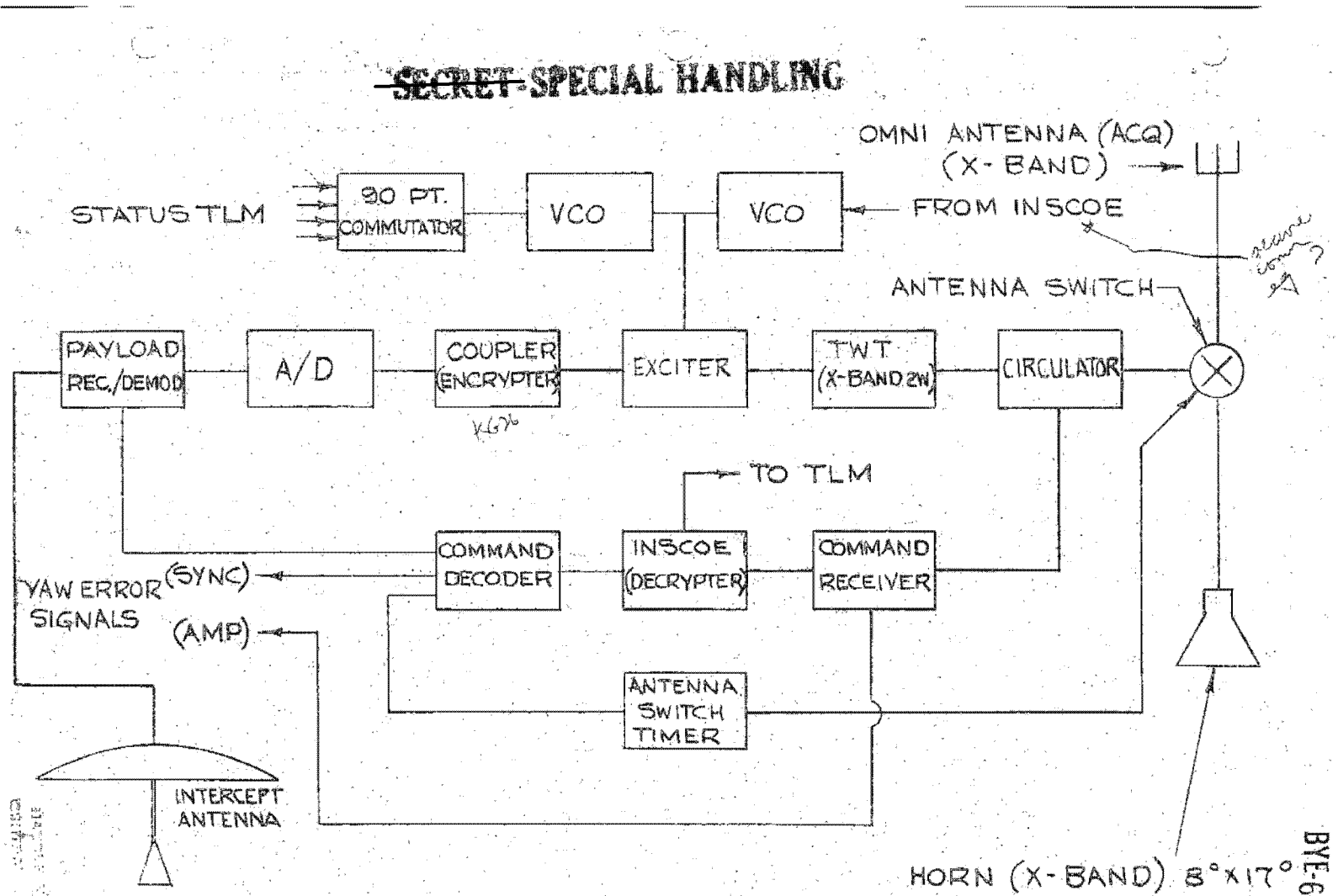

P-11 VEHICLE TLM, TRACKING & COMMAND BLOCK DIAGRAM

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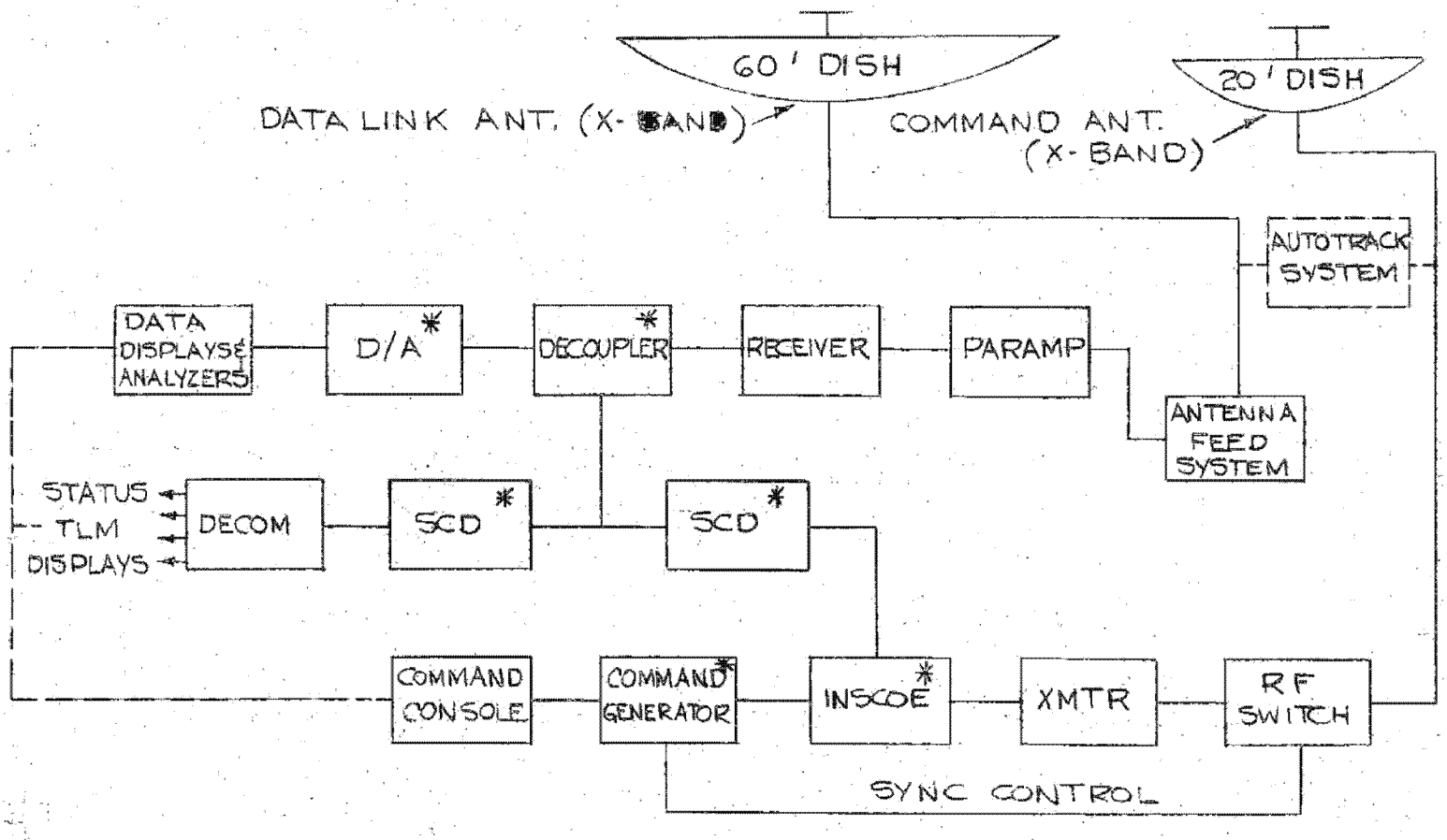

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GROUND SYSTEM BLOCK DIAGRAM

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* EXISTING HARDWARE

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T, T & C VEHICLE EQUIPMENT LIST

COMPONENT	WEIGHT (POUNDS)	POWER (WATTS)
o A/D CONVERTER	3	6
o COUPLER (ENCRYPT BOX)	7.5	8
o TM PACKAGE (VCO'S, COMMUTATOR)	2	2
o MODULATOR - TRANSMITTER (INCLUDES TWT & POWER SUPPLY)	14	16
o COMMAND RECEIVER	3	5
o INSCOR (COMMAND DECRYPT BOX)	4	9
o COMMAND DECODER	3	1.2
o ACQUISITION ANTENNA (OMNI)	1	0
o DATA LINK ANTENNA (HORN)	3	0
o ANTENNA SWITCH	1	0
o ANTENNA SWITCH TIMER	0.5	0.2
o ANTENNA ISOLATOR/CIRCULATOR	2	0
TOTAL	44 POUNDS	47.4 WATTS

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AW 0235[illegible]

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COMMAND SUMMARY

- DIGITAL CONTROL COMMANDS (11 BIT)

  1 ANTENNA POINTING COMMAND

  2 PAYLOAD FREQUENCY SELECTOR

  3 PAYLOAD BANDWIDTH AND SENSITIVITY SELECTOR

  4 SOLAR ARRAY CONTROL

  5 SPARE

  6 SPARE

  7 SPARE

- DISCRETE COMMANDS

  32 DISCRETE COMMANDS FOR VEHICLE CONTROL

- STORED PROGRAM COMMANDS

  NONE

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COMMAND LINK CALCULATIONS

FREQ. = 8 GC, RANGE = 19,700 NM

o	TRANSMITTER		
	. POWER (2.5 KW)	34	DBW
	. LINE LOSS	-2	DB
	. ANTENNA GAIN (20 FT., 0.43°)	51.5	DB
	. POINTING LOSS	-3	DB
o	PROPAGATION PATH		
	. FREE SPACE	-201.6	DB
	. ATMOS. LOSS	-0.3	DB
	. POLARIZATION	-3	DB
o	RECEIVER		
	. ANTENNA GAIN (OMNI)	-6	DB
	. LINE LOSS	-1	DB
o	RECEIVED SIGNAL POWER	-131.4	DBW
o	NOISE POWER (BW = 100 KC, NF = 6 DB)	-147.4	DBW
o	CARRIER TO NOISE	16	DB

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DOWN LINK CALCULATIONS

FREQ. = 10 GC, RANGE = 19,700 NM

o TRANSMITTER		
. POWER (2 WATTS)	3	DBW
. LINE LOSS	-1	DB
. ANTENNA GAIN (8° X 17°)	22.8	DB
. POINTING LOSS	-3	DB
o PROPAGATION PATH		
. FREE SPACE	-203.6	DB
. ATMOS LOSS	-0.3	DB
. POLARIZATION LOSS (YAW TRACKING)	-0.3	DB
o RECEIVER		
. ANTENNA GAIN (60 FT., 0.11°)	63	DB
. TRACKING LOSS	-1	DB
o RECEIVED SIGNAL POWER	-120.4	DBW
o NOISE POWER (T_s = 253°K, BW = 30 MC)	-129.8	DBW
o CARRIER TO NOISE (3.4 DB MARGIN ϕ LOCK	9.4	DB
o MODULATION IMPROVEMENT (D = 1)	8.7	DB
o SIGNAL TO NOISE	18.1	DB

T (ANT)	28°
T (LINE LOSS)	75°
T (NF = 1.5 DB)	150°
T (SYSTEM)	253°K

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SCHEDULE & PRICING

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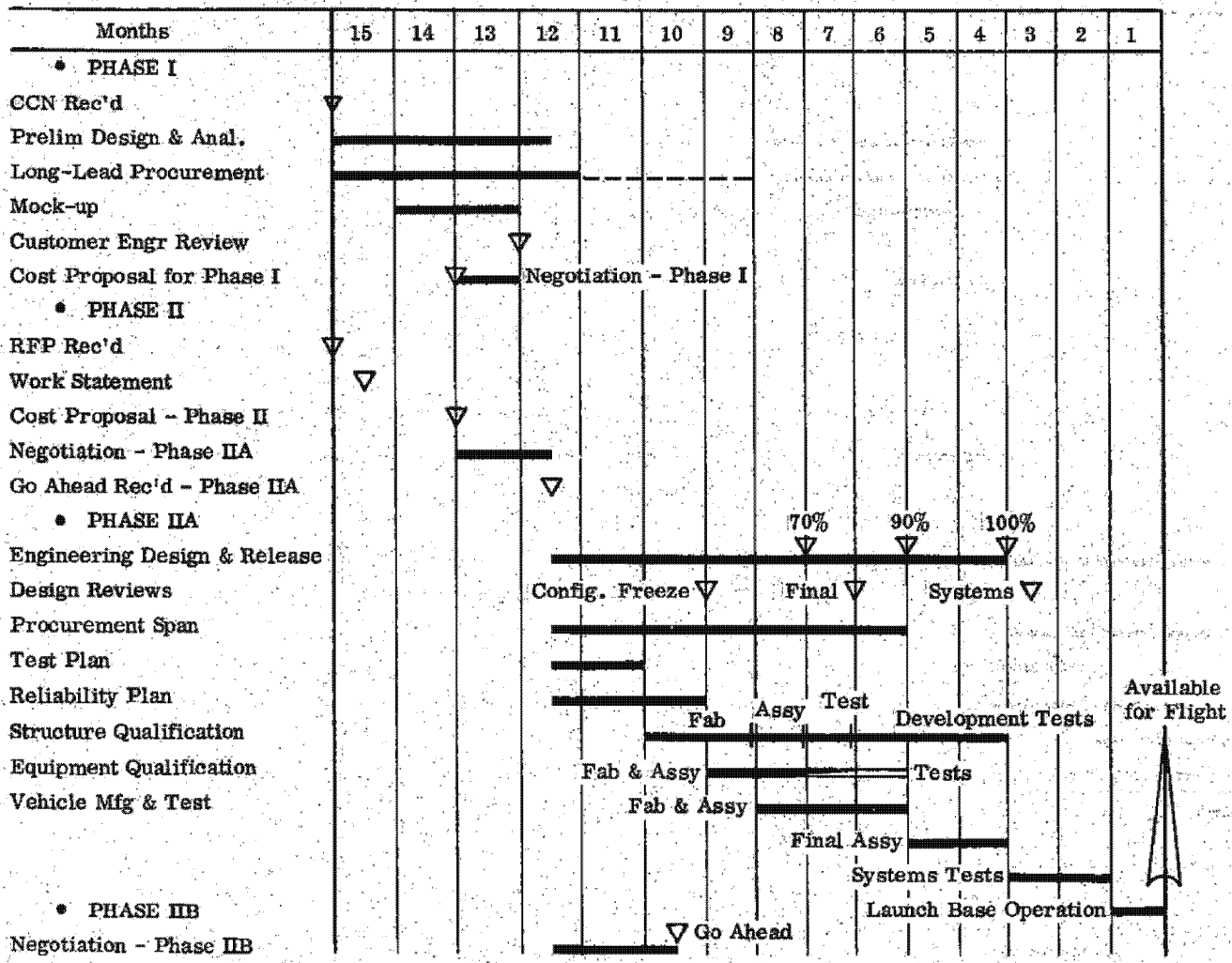
SYNCHRONOUS P-11 PROGRAM



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PRICE SUMMARY

			FIRST VEHICLE		RECURRING/ VEHICLE
o	SOLAR ARRAY		450		145
o	ATTITUDE CONTROL		935		170
o	ANTENNA		290		60
o	T. T. & C.		1.230		180
o	ENCRYPTER		620		55
o	PAYLOAD RECEIVER		500		300
o	P-11				
	. ANALYSIS/DESIGN	540		130	
	. DEVELOPMENT/QUAL.	385		-	
	. FAB/ASSY.	410		185	
	. SYSTEM TEST	130	1.465	80	395
		TOTAL	5.500		1.305
o	EXCLUDES:				
	. SPARES		700		-
	. KICK STAGE		500		150
	. LAUNCH & FLIGHT SUPPORT		175		125
	. CHECKOUT EQUIPMENT		550		-
	. ANTENNA FEED CHANGE		-		40
	. PAYLOAD RECEIVER CHANGE		-		200

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APPENDIX

HANDLE VIA BYEMAN

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OPTION #1

COMBINE MISSION 1 AND 2 IN SINGLE VEHICLE

- SINGLE FEED CAN BE DESIGNED FOR BOTH MISSIONS (DESIREABLE TO LIMIT LOW FREQUENCY TO 165 MC)
- VOLUME IS AVAILABLE FOR SECOND INTERCEPT RECEIVER - WEIGHT INCREASE 15 LBS.
- SIMULTANEOUS OPERATION OF BOTH MISSIONS POSSIBLE BY ADDING:

INTERCEPT REC.	15 LBS.	25 WATTS
ENCRYPTER	8	8
SOLAR ARRAY INCREASE	8	-
TOTAL	31 LBS.	32 WATTS

- REDUCES NUMBER OF GROUND STATION DATA AND COMMAND ANTENNAS BY ONE SET.
- CAN BE LAUNCHED TOGETHER WITH SECOND P-11 VEHICLE (MISSION 3) BY SLV 3X/AGENA/BURNER II BOOSTER SYSTEM. BURNER II ELIMINATES TWO KICK STAGES BY SERVING AS COMMON KICK STAGE.

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OPTION #2

COMBINE MISSION 1, 2 AND 3 IN SINGLE VEHICLE

- DESIGN OF ANTENNA FEED FOR ALL FREQUENCIES IS FEASIBLE.
- SIMULTANEOUS OPERATIONS WOULD REQUIRE:

INTERCEPT RECEIVERS (2)	30 LBS.	50 WATTS
ENCRYPTERS (2)	16	16
DATA TRANSMITTER	14	16
SOLAR ARRAYS	24	-
TOTAL	84 LBS.	82 WATTS

- VOLUME AVAILABLE AND 100% INCREASE OF SOLAR ARRAY CAPACITY NEEDS MORE STUDY.
- WEIGHT INCREASE RULES OUT USE OF TENTATIVE KICK STAGE DESIGN - NEXT AVAILABLE INCREMENT IS BURNER II OR EQUIVALENT.
- ONE SET OF GROUND STATION DATA AND COMMAND ANTENNAS FOR ALL THREE MISSIONS SIMULTANEOUSLY.

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